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Ex Post Sampling Risks and Decision Rule Choice in Substantive Testing

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Ex Post Sampling Risks and Decision Rule Choice in Substantive Testing

Abstract

In the present paper, we provide guidance to the auditor in selecting a statistical decision rule *ex post* to sampling. While the professional literature has recognized that the two most widely used decision rules provide equivalent *ex ante* sampling risks, empirical research has shown that substantial risk differences can arise *ex post* to sampling when underlying statistical assumptions are violated. We explain how such violations can cause risk differences and provide suggestions for pairing decision rules with statistical estimators based upon an *ex post* analysis of the sample evidence (e.g., error pattern).

The audit inference process involves the formulation and testing of propositions (hypotheses) about the auditee's internal controls and account balances. Statistical decision rules provide a means of determining whether audit sample evidence confirms or refutes such propositions. Two decision rules are employed widely when performing statistical tests of account balances. The Elliott and Rogers (E&R) [1972] decision rule specifies the conditions under which sample evidence supports the proposition that the account book value is fairly presented. Statement on Auditing Procedure (SAP) 54 [AICPA, 1972] presents an alternative decision rule based upon the proposition that the account book value is not fairly presented.

Implementation of either the E&R or SAP 54 decision rule, in classical variables sampling, requires the auditor to specify a preliminary estimate of the standard error of the mean and then determine the appropriate sample size so that the sampling risks of incorrect acceptance and rejection of the account book value (see Statement on Auditing Standards (SAS) No. 39) are less than allowable levels. Since the E&R and SAP 54 decision rules require the same sample size to provide equivalent (*ex ante*) sampling risks (see Roberts [1974]) and are based upon the same sample statistics (i.e., mean and standard error estimates), either decision rule can be employed to evaluate the fairness of the reported account book value *ex post* to sampling.

The professional auditing literature provides considerable guidance for the auditor's *ex post* (to sampling) decisions such as increasing

the sample size, selecting a fall-back estimator, and employing alternative audit procedures. However, guidance in deciding which decision rule to employ ex post to sampling has not been presented. Discussions in the professional literature have focused upon the decision to modify the E&R decision rule when the sample estimate of the standard error is larger than the preliminary estimate. Modification makes the E&R decision rule formally equivalent to the SAP 54 decision rule (see Roberts [1978, p. 251]) and, in concept, allows the predetermined risk of incorrect acceptance to be maintained.[1] However, when there are estimation problems, the actual risk of accepting a misstated account book value actually could be higher under the Modified E&R (or SAP 54) decision rule than under the E&R decision rule.

In the present paper, we provide guidance to the auditor in selecting (modifying) a decision rule ex post to sampling when traditional variables estimators are employed and underlying statistical assumptions are violated.[2] Recent empirical research indicates that such violations cause estimation problems and that their consequences are decision rule specific. Since the nature and severity of estimation problems depend both upon the characteristics of the accounting population and the particular estimator employed, postponing decision rule choice until after the sample evidence has been collected is advantageous and permits the auditor to pair decision rules with estimators.[3]

The remaining sections of the paper are organized as follows: In the second section, we discuss sampling risks from an ex ante

perspective and identify the relationship between inferential errors and audit outcomes under the E&R and SAP 54 decision rules. The third section presents a discussion of audit risk consequences *ex post* to sampling. Specifically, we explain how violations of underlying statistical assumptions can expose the auditor to different *ex post* risk consequences under the E&R and SAP 54 decision rules and identify the implications of recent empirical research bearing on their selection or modification when auditing asset accounts. Policy implications and concluding remarks are presented in the fourth section.

EX ANTE SAMPLING RISKS

When applying either the E&R or SAP 54 decision rule, the auditor explicitly or implicitly tests hypotheses about the auditee's account book value (see Roberts [1974]). Two types of inferential errors can arise when performing such tests. A Type I error, by statistical convention, results when a true null hypothesis is incorrectly rejected and the associated risk of this error is alpha (see Mood, Graybill, and Boes [1974]). Alternatively, a Type II error results when a false null hypothesis is not rejected and the associated risk is beta. Since the null hypotheses under the E&R and SAP 54 decision rules are different (see discussion below), the audit consequences of each type of inferential error also are different. In this section, we identify the relationship between inferential errors and audit outcomes under each decision rule.

The following null and alternative hypotheses have been associated with the E&R decision rule:

H_o: the account book value is correct (i.e., the monetary error, E = 0).

H_a: the account book value is misstated (i.e., E > TE, where TE denotes tolerable error, see SAS 39 [AICPA, 1981]).[4]

A Type I error, given the above hypothesis formulation, would likely result in the auditor's performing unnecessary tests before learning that the account book value actually is fairly presented.[5] Alternatively, a Type II error could result in the financial statements being materially misstated (see E&R [1972]).

The alternative SAP 54 decision rule can be formulated as the following hypothesis test (see Roberts [1974, p. 52]):

H_o: the actual monetary error (E) is greater than TE.

H_a: the actual monetary error (E) is zero.

Given the reversal of the auditor's null and alternative hypotheses under the SAP 54 decision rule, a Type I error could result in materially misstated financial statements, while a Type II error could result in the performance of unnecessary tests. Note that these audit consequences are the opposite of those under the E&R decision rule.

The difference between the audit consequences of Type I and Type II inferential errors under the SAP 54 and E&R decision rules was discussed by Roberts [1974], but is not widely understood.[6] More recently, SAS 39 addressed the inconsistent relationship between inferential errors and audit outcomes by introducing a new terminology which accommodates both decision rules. Specifically, as discussed above, SAS 39 refers to the risk of incorrect acceptance of the account book value and the risk of incorrect rejection of the account book value. The former risk is related to the effectiveness of the audit, while the latter relates to

audit efficiency. Hereafter, we avoid confusion with the hypothesis formulation by referring to the risk of incorrect acceptance as an effectiveness error and the risk of incorrect rejection as an efficiency error. An audit effectiveness error, therefore, refers either to a Type II error under the E&R decision rule or a Type I error under the SAP 54 decision rule. Similarly, an audit efficiency error refers to a Type I error under the E&R decision rule or a Type II error when the SAP 54 decision rule is employed.

While the relationship between audit consequences and inferential risks is different under the E&R and SAP 54 decision rules, Roberts [1974] has shown that the decision rules require the same sample size to maintain equivalent ex ante risks of effectiveness and efficiency errors. However, when there are estimation problems due to violations of underlying statistical assumptions, the ex post risk exposure can differ under the E&R and SAP 54 decision rules.

EX POST SAMPLING RISKS

In this section, we explain the nature and sources of differences in ex post sampling risks under the E&R and SAP 54 decision rules as a basis for guiding the auditor's selection of a decision rule ex post to sampling. Our analysis is facilitated by formulating each decision rule as a confidence interval. Under the E&R decision rule, the auditor would conclude that the auditee's account book value (X) is fairly stated if and only if

$$\hat{Y} - z_{\alpha/2} \cdot s/\sqrt{n} < X < \hat{Y} + z_{\alpha/2} \cdot s/\sqrt{n}, \qquad (1)$$

where:

$\hat{Y}$ ≡ sample estimate of the population account value

$s/\sqrt{n}$ ≡ sample estimate of the standard error for $\hat{Y}$

$z_{\alpha/2}$ ≡ standard normal deviate associated with a two-tailed α risk of incorrect rejection of H_o.

Following the SAP 54 decision rule, ex post to sampling, the auditor would conclude that the auditee's account book value is not fairly presented unless the computed upper precision limit for error:

$$|\hat{E}| + z_{\alpha/2} \cdot s/\sqrt{n} < TE, \tag{2}$$

where:

$\hat{E} = \hat{Y} - X$ ≡ point estimate of monetary error

$|\cdot|$ ≡ absolute value operator

Since both the E&R and SAP 54 decision rules require the same sample size (see Roberts [1974]) and are based upon the same sample estimates ($\hat{Y}$ and $s/\sqrt{n}$), decision rule choice can be postponed until after the sample evidence has been examined. A potential advantage of postponement is that the auditor can incorporate sample information about population characteristics (e.g., the accounting error rate and pattern), which have been shown to affect audit risk.

In the following subsections, we separately consider the ordinary mean-per-unit (MPU), stratified MPU, and auxiliary estimators. Separate analyses are required because, ex post to sampling, audit risk depends jointly upon the decision rule and estimator selected.

Ordinary MPU Estimator

Although the ordinary MPU estimator has limited applicability in practice (see Arens and Loebbecke [1981]), the present discussion provides a foundation for our analysis of other estimators. When accounting populations are highly skewed (see Stringer [1963]), ordinary MPU estimates based upon an average of the sample account book values also are likely to exhibit skewness and, thus, violate the assumption of normality used in constructing hypothesis tests or confidence intervals. In the presence of skewness, ordinary MPU estimates of the population mean (total) value also have been shown to violate the independence property of normal distributions by consistently exhibiting high positive correlation with estimates of the standard error (see Neter and Loebbecke [1975]).

There are important audit risk consequences associated with these violations of normality. For example, suppose the auditor is examining an asset account which is fairly presented, but whose subsidiary account book values are skewed to the right (i.e., the peak of the distribution is on the left and the tail extends to the right). In this situation, the distribution of sample MPU mean estimates for asset populations also would be skewed to the right, so a high proportion of sample estimates would fall below the actual population value. *Ceteris paribus*, two-sided confidence intervals computed under the E&R decision rule would not contain the actual population value as frequently as anticipated under the assumption of normality (see (1)).[7] Consequently, the risk of efficiency errors would be higher than the allowable level when the E&R decision rule is employed in conjunction with the ordinary MPU estimator. A

similar predisposition toward efficiency errors also exists under the SAP 54 decision rule, because a small sample mean estimate of the account value would result in a large point estimate of monetary error (see (2)).

The previous discussion of the effects of skewed mean estimates is incomplete, however, because correlation between the mean and standard error estimates also must be considered. Suppose, for example, that the auditee's asset account book value is fairly stated, but the auditor's sample estimate of the account mean (total) value is drawn from the lower region of the sampling distribution and, thus, is less than the actual mean (total) value of the account. Given positive correlation between sample estimates of the mean and standard error, a smaller than average mean estimate typically would be accompanied by a smaller than average standard error estimate. In this situation, the computed confidence intervals under the E&R decision rule not only would be centered below the actual mean, but also will be too narrow. Therefore, positive correlation reinforces the auditor's predisposition to commit efficiency errors when the E&R decision rule is adopted in conjunction with the ordinary MPU estimator.

The positive correlation between estimates of the mean and standard error can also increase the auditor's vulnerability to effectiveness errors under the E&R decision rule. For example, suppose that the auditor is examining an asset population which is misstated by an amount greater than TE. In this situation, positive correlation between estimates of the mean account value and standard error would imply that, when the mean (total) estimate is drawn from the upper tail of the distribution, the estimated standard error also will be larger than average. Since the computed confidence interval will be wider, the probability of

including the reported (overstated) book value in the computed confidence interval is increased. Therefore, if the account book value is misstated, the actual risk of effectiveness errors under the E&R decision rule would be increased due to positive correlation between estimates of the mean and standard error.

Alternatively, if the auditor were to employ the SAP 54 decision rule, positive correlation between estimates of the mean account value and standard error would have different audit risk effects. For example, suppose that the auditee's account book value is fairly stated, but the auditor draws a small mean estimate from the lower region of the sampling distribution. In this situation, positive correlation between estimates of the mean and standard error implies that both estimates would be smaller than average. The smaller than average estimate of the mean value results in a large point estimate of monetary error. However, the smaller than average standard error estimate has an opposing effect upon the computed upper precision limit for error (see (2)). Hence, the auditor's predisposition to commit an efficiency error would be lower under the SAP 54 decision rule than under the E&R decision rule, since positive correlation counteracts, rather than reinforces the effect of positively skewed mean estimates.

The auditor's risk of committing an effectiveness error also is lower under the SAP 54 decision rule than under the E&R decision rule. Assuming that the ordinary MPU estimate of the population value is large (i.e., the point estimate of monetary error is small) and, thus, close to the overstated account book value, a larger than average estimate of the standard error will increase the computed upper precision

limit for monetary error. Thus, the auditor's _ex post_ risk of committing both efficiency and effectiveness errors will be lower under the SAP 54 decision rule than under the E&R decision rule because positive correlation mitigates, rather than reinforces, the risk effects of (positively) skewed estimates of the mean.[8]

Stratified MPU Estimator

Auditors have attempted to counteract the effects of population skewness by stratifying the population before applying the MPU estimator. Empirical evidence presented by Neter and Loebbecke [1975] indicates that stratification, based upon the subsidiary account book values, makes achieved risk levels closer to planned by reducing the positive skewness of the mean estimates and the positive correlation between estimates of the mean and standard error. However, such stratification also makes the performance of the MPU estimator quite sensitive to the accounting error pattern.

While empirical evidence regarding actual accounting error patterns has been limited to asset populations, studies by Ramage, Krieger, and Spero [1979] and Johnson, Leitch, and Neter [1981] reported that accounting error patterns varied widely among auditees and for different asset accounts such as receivables and inventories. However, several general features were noted: (1) error-occurrence rates for receivables typically were lower than for inventories, (2) there were fewer understatement errors in receivables, so accounting error patterns exhibited greater skewness, and (3) the variability of accounting errors increased with the size of the underlying subsidiary account.

Empirical evidence (see Neter and Loebbecke [1975]) indicates that, in asset accounting populations in which the aggregate monetary error is small and individual errors are offsetting (i.e., both understatement and overstatement errors are present), stratified MPU estimates of the mean account value typically are skewed to the right and positively correlated with estimates of the standard error. Accordingly, the audit risk effects, although less severe, are essentially the same as for the ordinary MPU estimator discussed above. However, in populations in which the aggregate monetary error is large due to a preponderance of large overstatements, stratified MPU estimates of the population mean (total) value have been shown to exhibit negative skewness and negative correlation with estimates of the standard error (see Neter and Loebbecke [1975]).

The presence of negative skewness and correlation has important risk implications and, therefore, should be considered by the auditor in choosing between the E&R and SAP 54 decision rules. First, when the mean estimates are unbiased, but negatively skewed, a high proportion of sample mean estimates will be above the actual account value. Therefore, under the E&R decision rule, the statistical power to reject a population with a large overstatement error will be lower, so *ceteris paribus*, the auditor will be predisposed to commit effectiveness errors. A similar predisposition also exists under the SAP 54 decision rule, because a larger than average estimate of the account balance results in a smaller than average point estimate of monetary error.

Second, negative correlation between stratified MPU estimates of the mean account value and standard error implies that, when the

mean estimate is higher than average, the standard error estimate will be smaller than average. Under the E&R decision rule, such negative correlation counteracts the predisposition toward effectiveness errors; on those occasions when the mean estimate is higher than average and, thus, closer to the overstated account balance, the width of the confidence interval will be narrower than average due to a smaller than average estimate of the standard error. However, under the SAP 54 decision rule, negative correlation between estimates of the mean and standard error implies that, when the estimate of the population mean is higher than average, the point estimate of monetary error and standard error estimate both will be smaller than average. Since the computed upper precision limit for monetary error in (2) will be further reduced, the predisposition toward effectiveness errors (due to negatively skewed mean estimates) will be reinforced under the SAP 54 decision rule and, thus, higher than under the E&R decision rule. This result, of course, is just the opposite from that which would obtain if the stratified MPU estimates of the mean account value were positively correlated with estimates of the standard error (see discussion in previous subsection).

Empirical evidence for the stratified MPU estimator (see Duke, Neter, and Leitch [1982]) generally confirms the a priori reasoning presented above. Neither the E&R nor SAP 54 decision rule was found to be dominant across all asset accounting populations. Among populations in which the aggregate error was small (i.e., errors were small and offsetting and the sampling distribution would be expected to be positively skewed), the SAP 54 decision rule generally resulted in a

lower risk of effectiveness errors than did the E&R decision rule. However, in populations in which the aggregate monetary error was large due to large overstatement errors (mean estimates would be expected to exhibit negative skewness and correlation with standard error estimates), the E&R decision rule provided a lower risk of effectiveness errors.

Auxiliary Estimators

The auxiliary estimators (e.g., difference, ratio, and regression) are even more sensitive to the accounting error pattern than the stratified MPU estimator, because the relationship between the subsidiary book and audit values is used directly in estimating the population value. Previous research by Kaplan [1973], Neter and Loebbecke [1975], Baker and Copeland [1979], Beck [1980], and Duke et al. [1982] indicates that auxiliary estimates (both stratified and unstratified) of the mean account value are negatively skewed and negatively correlated with estimates of the standard error when accounting errors are predominantly overstatements. Furthermore, the auxiliary (squared) standard error estimates have been found to be biased downward when the variability of accounting errors increased with the size of the underlying subsidiary account book value (see Beck [1980]).

Ceteris paribus, negative skewness and correlation between estimates of the mean and standard error makes the risk of an effectiveness error higher under the SAP 54 decision rule than under the E&R decision rule (see the discussion of the stratified MPU estimator above). Biased (downward) estimates of the standard error make the computed confidence intervals tighter, so the probability of rejecting H_0 is further increased

under the E&R decision rule. A similar predisposition toward rejecting H_o also exists under the SAP 54 decision rule since the computed upper precision limit for monetary error would be reduced. But while the risk of committing an efficiency error would be increased by incorrectly rejecting the null hypothesis under the E&R decision rule, the probability of an effectiveness error would be increased under the SAP 54 decision rule (see Section 2).[9]

Beck [1980] reported empirical results for the regression estimator which were basically consistent with the statistical reasoning above. Among populations with a predominance of overstatement errors, the distribution of regression mean estimates exhibited negative skewness and negative correlation with associated estimates of the standard error. Accordingly, the auditor's exposure to effectiveness risks with the regression estimator was generally higher under the SAP 54 decision rule than under the E&R decision rule. Mixed results for the difference estimator were reported by Duke et al. [1982]. In populations with overstatement errors, however, their findings were consistent with Beck's. Accordingly, the limited empirical evidence for the auxiliary estimators indicates that, when accounting errors are predominantly overstatements, adoption of the SAP 54 decision rule can adversely affect the auditor's exposure to effectiveness errors.

POLICY IMPLICATIONS AND CONCLUDING REMARKS

In the present paper, we have explained how estimation problems can cause differences in sampling risks under the E&R and SAP 54 decision rules. We also have identified advantages of postponing decision rule choice until after the sample evidence has been obtained. Postponement

imposes no costs upon the auditor, because the same sample size is required to provide equivalent planned risk levels under the two decision rules. Furthermore, the auditor is able to consider possible risk differences between decision rules when the sample evidence suggests that underlying statistical assumptions appear to have been violated.[10]

We also have provided suggestions for the pairing of decision rules and statistical estimators. For example, we have explained why the risks of both effectiveness and efficiency errors are likely to be lower when the SAP 54 decision rule is paired with the ordinary MPU estimator. However, for other estimators such as the stratified MPU and auxiliary estimators, neither decision rule appears to be dominant across all types of asset accounting populations. Decision rule selection for these estimators should be based upon the characteristics of the population indicated by the sample. In particular, the auditor should consider the accounting error pattern; if the accounting errors observed in the sample are relatively small and include both overstatements and understatements (as has been found in inventory populations), then the SAP 54 decision rule would appear to be preferable. Alternatively, if the sample errors are predominantly large overstatements (as in accounts receivable), the E&R decision rule appears to be preferable.

Footnotes

1. By convention, statistical decision rules are specified before sampling to control the risks of incorrectly accepting and incorrectly rejecting the null hypothesis at predetermined (allowable) levels. When there are differences between preliminary and sample estimates of the standard error, however, the actual risk of incorrectly accepting the null hypothesis would be altered. Under the E&R decision rule, the null hypothesis is that the account book value is fairly stated (see discussion below) so differences between preliminary and sample estimates would change the auditor's risk of incorrectly accepting the auditee's account book value (see Roberts [1978]). Ex post to sampling, auditors can compensate by: 1) increasing the original sample size or modifying the standard normal deviate (z-value) used in testing the null hypothesis (or constructing confidence intervals). The latter modification would maintain the predetermined risk of incorrectly accepting the null hypothesis (account book value) by allowing the risk of incorrect rejection to vary and, thus, make the E&R decision rule formally equivalent to the SAP 54 decision rule (see Teitlebaum and Robinson [1975] and Roberts [1978, p. 251]).

2. We focus on classical variables estimators which are applicable to populations having expected error occurrence rates which are too high to make use of combined attribute-variables dollar-unit sampling (CAV-DUS) feasible (see Leslie, Teitlebaum and Anderson [1979]). Unlike CAV-DUS estimators, classical variable estimators have been widely used in conjunction with both the E&R and SAP 54 decision rules. Furthermore, the ex post risk differences between decision rules (discussed below) are due to violations of the normality assumption which is not required by most CAV-DUS methods.

3. Postponing the choice of decision rules provides two advantages. First, probable differences in comparative risk exposure due to violations of statistical assumptions, as indicated by the sample evidence (e.g., error pattern), can be considered in making the selection. Second, the task of modifying the E&R decision rule is avoided (see footnote 1 and discussion below).

4. The null hypothesis that $E = 0$ (rather than $E \leq TE$) has been adopted in the professional literature, since alpha risk is typically measured at the point, $E = 0$.

5. There also is a possibility that errors could be introduced in the accounts if the auditor were to persuade the auditee to make an adjustment to a fairly presented book value. However, this is unlikely to occur, because such an error would be identified by extending the audit tests and, therefore, corrected (see E&R [1972]).

6. For example, the introduction and glossary to the Audit and Accounting Guide: Audit Sampling (AGAS) (AICPA [1983]) adopt the E&R decision rule by equivalencing the risk of incorrect acceptance of the financial statements with beta risk (Type II error) and the risk of incorrect rejection with alpha risk (Type I error). However, the examples illustrating the calculation of upper precision limits in attribute sampling and dollar-unit-sampling (implicitly) adopt the negative formulation.

7. This reasoning, however, suggests that lower (one-sided) confidence intervals would contain a higher proportion of population values than planned. Empirical evidence confirms this expectation (see Neter and Loebbecke [1975]).

8. The same risk consequences also would be obtained if the auditor initially adopted the E&R decision rule, but modified the standard normal deviate *ex post* to sampling (see footnote 1). For example, suppose that $\hat{Y}$ and s are both larger than their respective means and, s also is greater than the preliminary estimate. In this situation, the auditor would reduce $z_{\alpha/2}$ so that the computed width of the confidence interval would be equal to the planned width. This modification, of course, reduces the probability that the confidence interval would erroneously include an account book value overstated by an intolerable amount and, thereby, decreases the risk of committing effectiveness errors under the E&R decision rule.

9. The same risk consequences also would obtain for the modified E&R decision rule. In the present context, the negatively biased estimates of the standard error would presumably result in the auditor's increasing $z_{\alpha/2}$ to make the actual width of the confidence interval equal to the planned width. However, the auditor's statistical power to reject the null hypothesis actually would be lower than implied by the biased standard error estimate. Hence, the auditor's *ex post* risk of committing effectiveness errors would be higher than planned.

10. The auditor also may wish to consider changing to a fall-back estimator (see Neter and Loebbecke [1975] and Roberts [1978]) or even applying alternative audit procedures as discussed in AGAS (AICPA [1983]). Qualitative as well as quantitative characteristics of the sample evidence should be considered in making these decisions.

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